

Quality Diagnosis in Complex Processes with Quality Function Deployment

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Abstract—The reasons influencing process quality are usually complexity. As the indetermination of roles between problem and cause, and their complex nonlinear relationship, many difficulties is appear for us to diagnose process quality and to determine relevant improvement measures. For Present researches in quality diagnosis, the basis is statistical control chart. The cause by diagnosis is direct. The underlying causes are not diagnosed on organization's system –level. And many of existing researches are based on deep knowledge. In practice, the staffs in a corporate are difficult to use it in practical. The paper employs partly the method of Quality Function Deployment (QFD) to treat with correlativity between issue and process, process and systemic factor, systemic factor and particular causation. Through the transformation of correlation matrix layer upon layer, the particular causation influencing output quality will be diagnosed and key measure will be determined subsequently. The research not only find cause from the system-level of an organization, but also easy to understand and apply. Case studies show the method is effectual. It is helpful for decision-making in quality improvement.

Keywords—Complicated processes, quality management, diagnosis, quality functional deployment, process improvement

I. INTRODUCTION

Quality diagnosis is very important in continuous quality improvement. When looking for opportunities to improve quality, quality problems need to be clear firstly. And then the causes of the quality problem are found. Quality diagnosis techniques often need to be developed in order to explain the relationship between the reasons and the problems. Model-based diagnosis is a common strategy behind many of the various techniques developed. Two types of techniques are common in model-based diagnosis [1]: One is often called ‘shallow model’, which relate effects to particular causes via pattern-derived (statistical) knowledge. Another is called ‘deep model’, which use analytical knowledge to relate effects to particular causes.

In deep level, the structural configuration and functional behavior of a system can led one to describe systematically a system and its faults [2]. The mathematical domain for such representation is discrete. The performances of process or variable are dissected into normal and abnormal range of behavior [3]. The mature quality diagnosis techniques are SPD: Statistical Process Diagnosis. Based on T^2 control chart, plenty of studies and various methods of SPD were proposed [4]. It includes: (1) Main composition analysis. (2) Bonferroni inequation method. (3) Differentiation analysis. Such as the research of Fault Diagnosis Based on Bayesian Network and T^2 analysis, the limits of Discrimination are determined based on Condition variable numbers in all Decomposition terms. The Fault variables are Identified easily [5]. Multivariate

quality diagnosis using LS-SVM Residual control chart is proposed else [6]. (4) T^2 decomposition. (5) Two type of quality diagnosis theory, which proposed by Professor Zhang [7]. Reference [8] shows its application.

Deep models, if they can be developed, offer the greatest diagnostic capability. However, although the SPD technology is very effective in practice, these technologies cannot be applied in the instance that process is not independent. In addition, many systems are so complex that only shallow models can be derived. In shallow level, Pattern Recognition for control chart is researched in Wavelet analysis and artificial neural networks [9]. Thissen *et al.* completed nonlinear and multi-variable statistical process diagnosis with bottleneck neural network to replace primary composition analysis (PCA) or partial least square (PLS) with data linear structure [10]. Hassan improved existing tools of monitoring and diagnosis. Input vectors of pattern are statistical characteristic by eliciting and section from original data. SPC recognition based on performance is appraised through analyzing and comparing recognition based on original data [11]. Cosmin and Jose *et al.* adopt fuzzy classification diagnosed the fault [12]. Products manufacture quality diagnosis based rough-set is provided [13][14]. the dynamic relationship among influence factors (condition attributes) and product quality characteristics (decision attributes) are established in the use of decision tables. By calculating the importance of influence factors, the source of variation is identified[13]. The researches show that the shallow model can relate effectively to particular causes by integrating all kinds of experience and techniques without analytical knowledge and in the case of no accurate quantitative data.

For Present researches in quality diagnosis, the basis is statistical control chart [15][16][17][18]. And the cause by diagnosis is direct. The underlying causes are not diagnosed on organization's system –level. Besides, a large numbers of existing researches are based on deep knowledge. In practice, the staffs in a corporate are difficult to understand and master these methods accurately. It is difficult to be used in practical. The more simple and effective method, the easier it is to be applied in reality. For this, the diagnosis method for cross-function quality with Quality Function Deployment (QFD) is proposed in this paper. The research of quality diagnosis in the paper not only find cause from the system-level of an organization, but also easy to understand and apply.

Cross-function diagnosis is done along with the process flows that cross the pyramid structure of an organization [19]. The diagnosis process begins from the symptoms, and then investigating the process causes of problem. In methodology,

Quality Function Deployment (QFD) is partly used to analyze the correlativity between issue and process, process and systemic factor, systemic factor and particular causation. Correlation matrixes are constructed layer by layer. Particular causes are determined by integrating all kinds of experience and techniques. In this process, shallow model is useful. In the paper, above thinking is researched by a case study. Diagnosis is a day-to-day management activity in a company. Gradually, it should become a company diagnosis culture.

II. DIAGNOSIS MODEL OF PROCESS ORGANIZATION

In process organization, output dependent on the relevant process, and the process performance lie on the system factors acting on process. Such thinking that anti-causality gives a route for quality diagnosis. I.e. diagnosing step-by-step beginning from the result to process, and then from process to factors. Ultimately find the root causes of problems. The causes bring quality problems may be attributed to process, or may also be attributed to design of systemic factors act on the process. Quality diagnosis is to identify the causes of problem at all levels of organizations. When causes are found beyond this level, further diagnosis will be moved to the former levels, such as systematic factor level. It ends until the root causes are found. As processes and systems factor related to many relevant departments, when diagnosis aims mainly at process and systematic factor, it is necessary to get relevant personnel in different departments together to do cross-functional diagnosis, which offer a platform for communication in all departments.

Figure 1 is a diagnosis model of process organization. The processes and their relationship are shown in oval. Systematic factors that act on these processes are shown on the upper part of chart, and process resources are shown on lower part of chart. Main processes influence external results R1 are shown in Shadow. EI is external input, and IP is input of internal process.

Each process has a number of targets that are the input of follow process, and that must meet the requirements of follow process. For example, the targets of process P2 must meet the requirements of process P1 (customer process). Process P1 must ensure the quality of output R1.

The detail diagnosis route as follow: Firstly, relevant processes relate to external result R1 are analyzed. These main processes owner are gotten together and constituted a control team to assess presumably which processes and quality factors could bring output R1. Preliminary assessment is not necessarily accurate; because the assessment will be modified again and again with the diagnosis got along with anti-causality. In figure 1, shadow shows there are four processes (P1, P2, P3, and P4) influence output R1. Then, the control team draws all diagnosis routes as soon as possible. That is showed in the gray dotted line In Figure 1

Diagnosis route begin from the interface process contact directly with external customers, such as P1 in Figure 1, and then diagnose employ appropriate diagnostic methods. Process P1 is decomposed as sub-processes if P1 is complicated. In process P1, the causes of the problem may be found or couldn't be found. For latter, Diagnosis usually need to be

moved forward to next process along the process route (P2 and P3, in figure 1). Analysis is continued along the converse 'process flow' in this route, until the causes of problem that measures can be taken are found. In this process, the original diagnosis routes may need to make amendments. On the other hand, some processes has eliminated originally may need to re-consider, because they are found to play likely an important role in the following analysis. Sometimes a particular process may play an important role, but the root cause may be systematic factors. The diagnosis should be extended until all system factors are analyzed and the processes as input are marked (the IP5 in figure 1). When diagnosis is extended to external input, the importance of external input for problem must be evaluated. If the input is very important, the control team should decide to extend the diagnosis to supplier's process (EXT.P in figure 1). Otherwise, the route should be cutout, and the analysis is continuing in other relevant areas relate to suppliers (e.g. EI1 in figure 1).

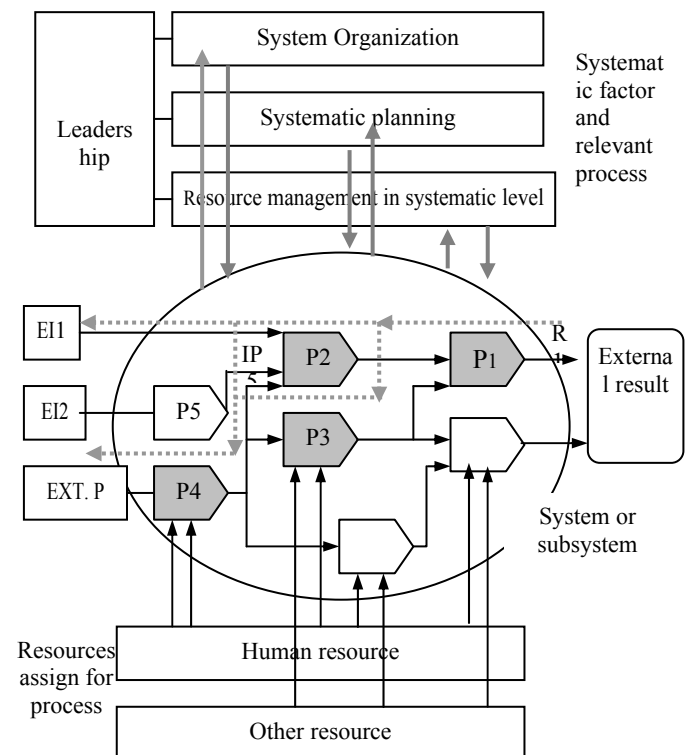


Figure 1 diagnosis model for process-oriented organization

With the diagnosis, the process causes will be gradually identified. In the process analysis, some systematic causes may be accurately identified. Those causes relate to the process providing "internal product". Such as training, procedures, plans (input IP5 in Figure 1). Others maybe can only be made a hypothesis, which require further confirmation. Repeated and systematic causes (such as organization weakness) diagnosis can provide important information for diagnosis. Therefore, the root causes that having not been found are required to list one by one.

III. DIAGNOSIS FOR COMPLEX PROCESS USING QFD

For a single, relatively simple problem, a satisfied diagnosis out-put may be got by using fishbone diagram. In

reality, however, there are often a large number of complex, interrelated issues. Once the result is not satisfaction, it is necessary to diagnose the cause of the problem and make plan for performance improvement. At this time, a large number of complex issues and causes need to be diagnosed. For example, when customer's satisfaction is a problem, first of all, the reasons of customer's dissatisfaction need to be identified, and then relevant process' state are identified by comparing with competitors. There is many causes influence customer's satisfaction. Such as: slow response time, inadequate technical capacity, improper resource assignment, no problem-solving telephone services, poor logistics, low reliability of products, the lack of communication with customers, and so on. In a large number of possible causes, the factors of each cause are complex, and each cause is got from many of process flow. Therefore, each of which need to be constructed a fishbone diagram respectively. With the increase of branches number, fishbone diagram would gradually become more and more complex. That relevant weight, quantitative data, and others become more difficult to identify. It is so especially when analyze the relationship among the branches that can't be tracked, and among different charts from same result.

In order to solve the problem above, a matrix-based method is adopted to diagnose for cross function. I.e. the part of philosophy and structure of Quality Function Deployment (QFD) are employed for diagnosis [20]. It is a systematic and easy-to-use tool for cross-function. The diagnosis program based on QFD is as follows:

Firstly, one or more "process flow" charts relevant problems (result) are drawn in the basis of figure 1. And an interface is inserted between 'process flow' and customer. The interface plays a link role, and figure to whole company customer-oriented. As figure 2 shows, PF is whole process flow. Box PF can be extended to each sub-PF process if necessary.

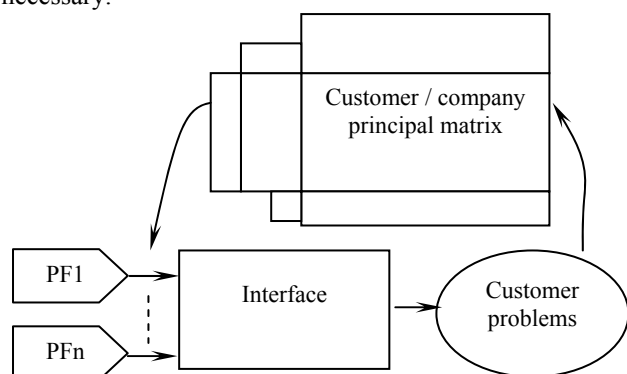


Figure 2 Process flow charts

Then, the customer's problems are deployed along with the converse to "process flow" using QFD matrix. The causes of the problem are diagnosed layer by layer, as shown in figure 3.

In second layer sub-matrix, quality defects (output from principal matrix) are assigned to company's processes. If necessary, the outputs from the second layer (process causes of result) are converted into the systematic factors, i.e. the

third layer sub-matrix is constructed. It does not stop until the measurement can be made in the cause.

To understand above process in detail, the next section will give an example to diagnose service process quality.

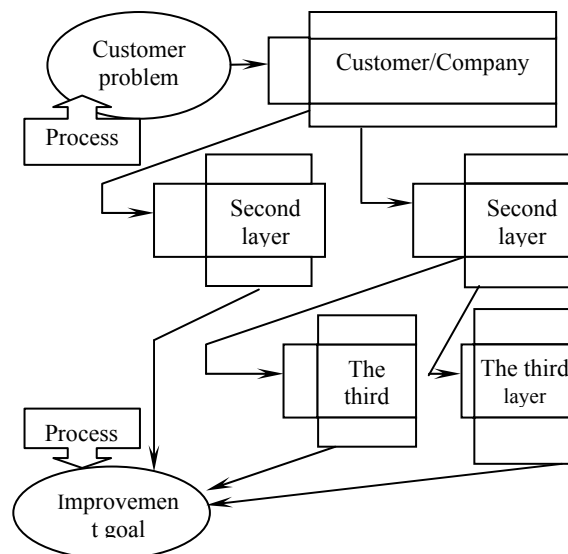


Figure 3 A series of diagnosis

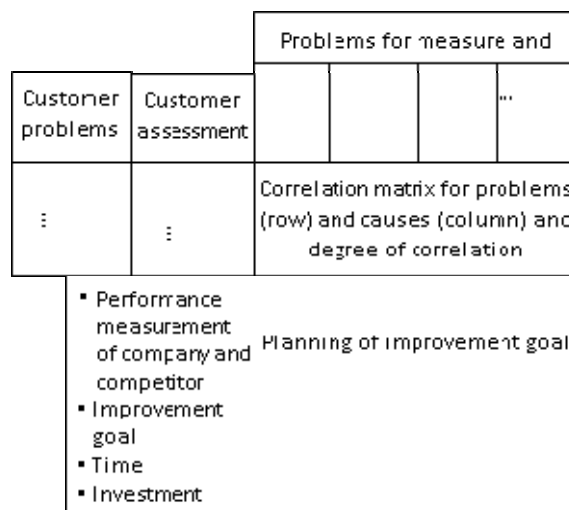


Figure 4 General Principal Matrix of company/customer

IV. CASE STUDIES

In a company's after-sales service, the quality problems customer perceived, Found by surveys, include communication barriers, product's recurrent fault, service delay, and inadequate new product and services. These problems, expressed in customers' language, cannot be measured by available means, need to be converted in company's language, i.e. converted to quality attributes measurable. For example, the problem "services delay" can be converted into quality attribute the gap between the actual service time and the longest assuring service time (when the gap is zero, it denote the service providing in the assuring time). In order to make the cause (controllable) significant, the

whole time is usually divided into a number of important periods of time. Here, it is divided into the preparation time for service, diagnosis time and repair time. In this way, the goal can be determined in each of periods respectively, and the relevant difference can be measured.

For this, the Customer/company principal matrix can be constructed in the interface between customers and the companies. Figure 4 shows the general customer / company principal matrix. The chart not only expresses all service problems gotten from survey of customer's satisfaction, but also describes the problem that need to be chosen in diagnosis. At the same time, services problem provided by customer, by the chart, can be converted into company's problems so as to be measured and diagnosed easily. Compared with the fishbone diagram, the method based on the matrix has usually great advantages in the analysis of problem with interaction.

Figure 5 will be passed on the cases of specific Figure 4, shows the customer / company principal matrix. Each of problems provided by customer is given a weight. Weight, can be gained through a survey of customers' perception, is a result of combination of company's customer assessment and competitor's performance assessment. The weight values are set vary from 1 to 5. Firstly, the results determined by company's assessment and by competitor's assessment are shown on the second column and the third column in Figure 5 respectively (here, only one competitor is considered). Then, the weight value of each problem is identified respectively by analysis of two types of results above (shown on the first column in Figure 5). Finally, the key problems focused on market are determined (on the fourth column in Figure 5). If necessary, the improvement goals, determined by the score of customer assessment, may be set at this stage (shown on the fifth column in figure 5).

The qualities problems customer perceive are shown on the right-hand of upper part in Figure 5 after described in company language. The problems described must be able to measurement. The causes of the problem may be attributed to the implementation of some activity, or may be due to the lack of an activity. Therefore, in order to diagnose, the problems perceived by customer must be converted into diagnosis problems (causes or corrective measurements). The causes of the problems and the corrective measurements are shown on head of the table of each column respectively in Figure 5.

The right-hand of the middle part shows the correlation of rows and columns of matrix. Three symbols associated with three of the degrees of correlation. The black spots "●" denote strong degree of correlation (the main cause of problem perceived by customer is the corresponding diagnosis problem), dual empty Circle "◎" denote middle degree of correlation, and empty circle "○" denote weak degree of correlation. Each symbol can be assigned to a quantitative value. In this example, each quantitative value is 9, 4 and 1 respectively.

"Absolute importance", Lower part next matrix in figure 5, is gained by converting matrix. The absolute importance for diagnosis item equals the sum of all weight of customer problem multiply relevant degree of correlation. For instance,

absolute importance of Prepare, diagnosis, supporting activity is

$$4 \times 4 + 3 \times 1 + 5 \times 9 = 64.$$

Relative importance is the ratio that each absolute importance to sum of all absolute importance. For instance, relative importance of Prepare, diagnosis, supporting activity is

$$\frac{64}{27+64+57+56+63} \times 100 = 23.97$$

Measurement and improvement plan, Lower part of matrix in figure 5, include current measurement of average of problems and key element. If the improvement is regarded as a challenge to capability and knowledge, not response statically, the goals and improvement targets need to be constructed according the requirements of competitive environment (not based on what company can do). Improvement should be based on the requirement of survival, development and success to improve the company's enable.

Therefore, initial improvement targets should be constructed in low-half part of matrix to analysis further after the measurement has been completed. Once to find the root cause of the problem, we can develop improvement measures.

The last line is "List for further analysis". For each improvement plan relevant column, when a specific measure is difficult to put forward, the problem need to been decomposed to company's processes. Here, the mark 1 is played in relevant column.

To simplify the paper, the second matrix of third sub-matrix is only analyzed. Figure 8 describes the second matrix of third layer sub-matrix derived from the second layer matrix Figure 7. In this sub-matrix, the row "further to system factors" is added, which marked with the numbers 1-5 to distinguish the "system factor category", where 1 is leadership, 2 is strategy and plan, and so on. The letter is used to identify the specific factor of "system factor category". System factors diagnosis are not started until cross-function diagnosis has been accomplished and all possible system factors have been found.

In second layer matrix, diagnosis items in principal matrix are assigned to company's process. We further analysis the causes of "service delay" and "inadequate new product and services" According to the analysis of the matrix (focus on the column that the "list for further analysis" is "1"). The second, third, fourth and fifth column in figure 5 are mainly considered. First, the "process flow" relate to diagnosis item is drawn according to actual situation. Then, second layer sub-matrix is constructed based on the "process flow". Namely process flow of Figure 2 is reified according to the requirement of item. The reified process flow as shown in Figure 6.

If the column 2, 3, 4 and 5, in figure 5 as input, the process and input in Figure 6 as output, the second layer sub-matrix is established as Figure 7. In the second layer sub-matrix, figure 7 (or all of the sub-matrix), It should be noted that the upper layer matrix output is assigned to the process. So, the degree of correlation in cross of row and column is described with

relative importance, that is, percentage of weight (less than 1). Thus, in each column of each matrix, the value of degree of correlation always represents the percentage weight of column cause.

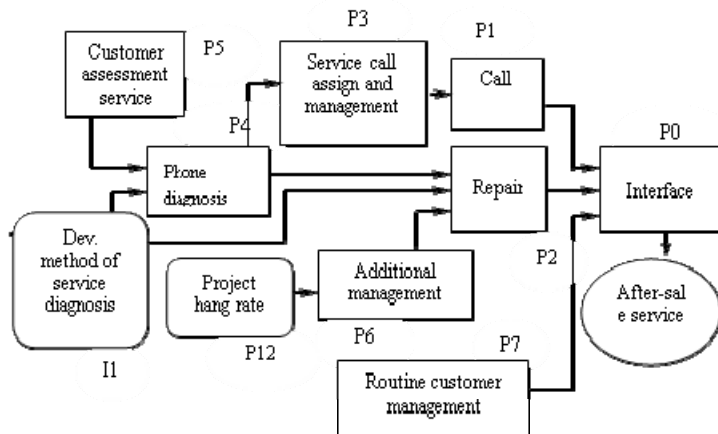


Figure 6 Process flow

In sub-matrix (Figure 7), the data of “relative importance” can be arranged with Pareto in order to determine which branches should be retained in cause-tree, and which can be ignored. In this case, the operation-related causes will be analyzed in “false repair” and “routine customer management”.

In order to avoid the expansion of matrix, five processes related to repairs, anterior 5 column in figure 7, i.e. process 1-5, are get together to be constructed a first matrix of third layer sub-matrix. In Figure 7, the five columns relevant “List for further analysis” are all marked with 1. The last column marked with 2, is constructed the second matrix of third layer sub-matrix. Lower layer Matrixes can be further created from these two sub-matrixes, until the root causes are found.

To simplify the paper, the second matrix of third sub-matrix is only analyzed. Figure 8 describes the second matrix of third layer sub-matrix derived from the second layer matrix Figure 7. In this sub-matrix, the row “further to system factors” is added, which marked with the numbers 1-5 to distinguish the “system factor category”, where 1 is leadership, 2 is strategy and plan, and so on. The letter is used to identify the specific factor of “system factor category”. System factors diagnosis are not started until cross-function diagnosis has been accomplished and all possible system factors have been found.

Cross-function diagnosis completed based on the above method may decompounds the quality problems into company's specific process and system factors. The cause-effect chain may be clearly formed in company's complex process. At the same time, the performance improvement would be guaranteed in measure route based on reliable indicators, because the cause-effect matrix may make a company working out improvement planning related to diagnosis (when the lower part of matrix is full in), it can be done even if in the planning process with interaction.

V. CONCLUSIONS

Cross-function diagnosis based on QFD matrix is effective in the processes with high interaction. Through the method described in the paper, series of matrix may be gradually constructed one by one with the adjustments going back continually. In each matrix, the rows are assigned as the results, and the columns are related to relevant causes or corrective measures. Diagnosis can be begun from brainstorming. But prior assumptions must be validated by quantitative data. This means that we must always increases or amend data of the matrix, specifically when percentage weights are estimated to causes of result. This method can also be used to measure the current performance, and to work out improvement goals and current improvement targets.

As data can be easily assigned and disposed in the matrix, only developing specific software may provide useful support. Once the upper matrix is adjusted, the sub-matrix can be automatically updated by program. This updating capability obviously has huge advantage for the process with high interaction.

When content in sub-matrix returned to the principal matrix, the principal will matrix becomes a “blueprint” of improvement planning. All owner of relevant process can return each variation refer to these “blueprint”. In addition, if such diagnoses become a company's methodology, the company will have a significant impact on the culture. Then diagnostic methods will train an extensive diagnostic culture through contact problems rationally and orderly. The diagnosis culture is especially significance for learning Organization.

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REFERENCES

- [1] J. B. Yang, B. G. Dale and C. H. R. Siow, “Self-assessment of excellence: an application of the evidential reasoning approach”, *INT. J. PROD. RES.*, Vol. 39, No. 16, pp. 3789-3812, 2001.
- [2] L. Pau, *Failure Diagnosis and Performance Monitoring*, Marcel Dekker, New York, 1981.
- [3] K. Dooley, and S. Kapoor, “An enhanced quality evaluation system for continuous manufacturing processes, part 1: theory”, *Journal of Engineering for Industry*, No. 112, pp. 57-62, 1990.
- [4] X. C. Lou and F. Ruan, “Review for product quality management” (in Chinese), *Machine and Hydraulic pressure*, No13, pp.13-15, 2004.
- [5] W. D. Cheng, *Research on Approaches of Fault Diagnosis Based on Bayesian Network and Multivariate Statistical Analysis* (in Chinese), A Dissertation Submitted to Shanghai Jiao Tong University for the Master Degree, Feb. 2011.
- [6] X. Q. Song, *A Research about Multivariate Quality Diagnosis Using LS-SVM Residual Control Chart* (in Chinese), Nanjing University of Science & Technology Master Dissertation, Jun. 2010.
- [7] G. X. Zhang, *Two-type quality diagnosis theory and its application* (in Chinese), Science Press, Beijing, 2001.

Customer problems	Customer assessment			Problems for measurement and diagnosis						
	Weight	Company	Competitor	Key element	Goal	Rate of defect	Prepare, diagnosis, supporting activity	Repair	Voice of Customer phone	Customer management
Communication barriers	4	4	4				◎		●	●
Recurrent fault	3	3	3	★		●	○	◎		
Service delay	5	2	4		4		●		◎	
Inadequate new product and services	3	1	3							●
Absolute importance						27	64	57	56	63
Relative importance						10.11	23.97	21.35	20.97	23.6
Measurement unit						100 customer	Minute	Hour	1-5 Score	1-5 Score
Current status						20	35	8.2	3	3
Key element						2	5	5	3	4
Target							<15	<6	4	4
Goal							<10	<4	5	5
List for further analysis							1	1	1	1

Figure 5 Principal matrix of company / customer

Output of The principal matrix	Relative importance	Measure unit	performance	Key element	Goal	Target	Process or unit							
							P1	P2	P3	P4	P5	P6	11	P7
							Call to customer	Repair	call assign ; management	Phone diagnosis	Customer assessment service	Additional management	Dev. method of service diag.	Rout. customer. management
Prepare, diagnosis, supporting activity	23.97		35	5	<10	<15			0.20	0.20				
Repair	21.35		8.2	5	<4	<5	0.10	0.25	0.40		0.051			0.70
Customer call	20.97	1-5 minute	3	3	5	4				0.30				0.59
Customer management	23.6	1-5 minute	3	4	5	4								0.466
Relative importance							2.13	5.34	13.33	10.8	1.09			38.28
Measure unit														
Current performance														
Key element														
Target														
Goal														
For further analysis							1	1	1	1	1			2

Figure 7 Process sub-matrix

Second layer output	Sub-process or unit								
	Relative importance	Customer case	Customer visiting plan	Active complaint management	New product information	Retain policy	Training	Lose customer survey	Customer communication
Routine customer management	38.28	0.1	0.1	0.05	0.05	0.25	0.20	0.05	0.20
	Relative importance								
	Measure unit	1-5 Minute	5 Minute	1-5 Minute	1-5 Minute	1-5 Minute	1-5 Minute	Yes/no	5 Minute
	Current performance	2	1	1	3	1	2	No	1
	Key element	5	5	2	2	5	4	3	5
	Organization difficulty	M	L	M	L	H	M	L	M
	Target	5	5	5	5	4	4	Yes	5
	Goal	5	4	4	4	3	4	Yes	5
	Further to system factors					1.a	1.c		

Figure 8 Third layer matrix (H: high, M: middle, L: low)

- [8] X. D. Li, L. C. Wang, "The improvement in Performance evaluation by Two type of quality diagnosis theory" (in Chinese), Statistics and Decision, pp.184-186, sept. 2010.
- [9] H. F. Zhou, "Overview on Pattern Recognition of control chart based on Wavelet analysis and artificial neural networks" (in Chinese), Journal of Chifeng University (Natural Science Edition), Vol. 27, No. 5, pp.96-97, May 2011.
- [10] U. Thissen, W. J. Melssen, and L. M. C. Buydens, "Nonlinear process monitoring using bottle-neck neural networks", Analytica Chimica Acta, p. 446, pp. 371-383, 2001.
- [11] A. Hassan, M. N. B. Shariff, A. M. Shaharoun and H. Jamaluddin, "Improved SPC chart pattern recognition using statistical features", International Journal of Production Research, Vol. 41, No. 7, pp. 1587-1603, 2003.
- [12] D. B. Cosmin, S. C. Jose and P. Vasile, "A novel fuzzy classification solution for fault diagnosis", Journal of Intelligent & Fuzzy Systems, No. 15, PP. 195-205, 2004.
- [13] F. F. Zhao, *A Study on Manufacture Process Quality Control and Diagnosis Methodology for Customized Product* (in Chinese), Tianjin university PhD thesis, Aug. 2010.
- [14] H. T. Liu, J. M. Zhai, X. Xu, "Rule Acquisition of Production Processes Quality Based on Variable Precision Rough Set" (in Chinese), MACH INETOOL & HYDRAULICS, Vol.38, No. 9, pp.94-97, May 2010.
- [15] G. L. Luo and S. Y. Qin, *The Basis of intelligent Control*, Zhejiang University Press, Zhejiang, 1997.
- [16] V. N. Vapnik, *The Nature of Statistical Learning Theory*, Springer Verlag, New York, 1995.
- [17] R. A. Brooks, "A robust layered control system for a mobile robot", IEEE Journal of Robotics and Automation, RA22 (1): PP. 14 -23, 1989.
- [18] L. Custodio, R. Ventura and F. C. Pintor, "Artificial emotions and emotion2based control systems", Proc. ETFA'99, Barcelona: IEEE Publication, pp. 415-1420, 1999.
- [19] T. Conti, *Organizational Self-Assessment*, Chapman & Hall, 1997.
- [20] D. B. Zhuo, J. C. Xu, *Diagnostic quality assessment focusing on process improvement* (in Chinese), chapter 7, China Machine Press, Beijing, 2005.